ARL-TR-7619 • MAR 2016

US Army Research Laboratory

WIAMan Technology Demonstrator Sensor Codes Conforming to International Organization for Standardization/Technical Standard (ISO/TS) 13499

by Michael Tegtmeyer

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US Army Research Laboratory

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REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
March 2016

2. REPORT TYPE
Final

3. DATES COVERED (From - To)
September–December 2015

4. TITLE AND SUBTITLE
WIAMan Technology Demonstrator Sensor Codes Conforming to International Organization for Standardization/Technical Standard (ISO/TS) 13499

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Michael Tegtmeyer

5d. PROJECT NUMBER
WIAMan

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army Research Laboratory
ATTN: RDRL-DPW
Aberdeen Proving Ground, MD 21005-5066

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TR-7619

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
primary author's email: <michael.b.tegtmeyer.civ@mail.mil>.

14. ABSTRACT
The International Organization for Standardization (ISO)-Multimedia Exchange task force is responsible for maintaining the specification for the multimedia data exchange format for impact tests outlined in Technical Standard 13499. This specification includes what is informally known as an ISO Channel Code, which encodes the test object, location, physical dimension, and other information related to a physical measurement in a 16-character machine-readable format. There exists a standardized and published list of ISO Channel Codes for measurements taken with existing anthropomorphic test devices (ATDs). The Warrior Injury Assessment Manikin Project is in the process of developing an ATD specific to the under-body blast environment and requires ISO Channel Codes specific to this dummy.

15. SUBJECT TERMS
sensors, channel codes, ATD, multimedia exchange format, ISO/TS 13499

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Michael B Tegtmeyer
Unclassified	Unclassified	Unclassified	UU	36	19b. TELEPHONE NUMBER (Include area code) 410-278-6074

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

List of Tables

1. Introduction

The International Organization for Standardization (ISO)-Multimedia Exchange task force is responsible for maintaining the specification for the multimedia data exchange format for impact tests outlined in ISO/Technical Standard (ISO/TS) 13499.[1] This specification includes what is informally known as an ISO Channel Code that encodes the test object, location, physical dimension, and other information related to a physical measurement in a 16-character, machine-readable format.

There exists a standardized and published list of ISO Channel Codes for measurements taken with existing anthropomorphic test devices (ATDs). The Warrior Injury Assessment Manikin (WIAMan) Project is in the process of developing an ATD specific to the under-body blast environment and requires ISO Channel Codes specific to this dummy. This document outlines the selection philosophy for the chosen codes and describes the location and code for each body region. A summary of all Channel Codes assigned to the WIAMan dummy is provided in the Appendix.

2. ISO Channel Code Overview

The ISO Channel Code is a string of 16 alphanumeric characters that are a composition of 9 position-specific substrings that encode details of a measurement. Each substring has an associated list of valid values. The substrings and their meaning are as follows:

Test object Code position 1: This substring represents the test object. For example, the test rig, vehicle and number, or pendulum.

Position Code position 2: This substring represents the spacial or descriptive location of the test object. For example, front-left, second-row, or Seat X.

Main Location Code position 3–6: This substring represents the spacial or descriptive location of the channel within the test object. For example, head, heel-plate, or seat pan. It is also used to describe calculated or other channels such as the Head Injury Criterion, customer identification code, or time reference signal.

Fine Location 1 Code position 7–8: This substring represents the spacial or descriptive location sub-qualifier associated with the main location. For example, upper, center-of-gravity, or pretest.

Fine Location 2 Code position 9–10: This substring represents the spacial or descriptive location sub-qualifier associated with the fine location 1. For example, upper, compression, or raw data.

Fine Location 3 Code position 11–12: This substring represents the spacial or descriptive location sub-qualifier associated with the fine location 2 or the test object itself. For example, upper, pretest, or Hybrid III mid-sized male ATD.

Physical dimension Code position 13–14: This substring represents the type of the physical measurement associated with the channel. For example, acceleration, force, or time.

Direction Code position 15: This substring qualifies the spacial direction of the measurement if present. For example, resultant, lateral, or vertical.

Filter Class Code position 16: This substring denotes any signal processing filter applied to the measurement channel. For example, CFC 1000, prefiltered, or without.

3. Selection Philosophy

The WIAMan ATD is a modern, high-channel count dummy that shares many attributes with other, newer dummies. It also breaks new ground in terms of volume of possible quasi-static measurements due to its embedded and distributed data acquisition system. In general, established position code selection have been used to create an unambiguous code string wherever possible. There are some cases however, that this coding style breaks tradition in favor of more recent coding styles such as those used with the WorldSID.[2] These differences are outlined in the following subsections.

3.1 Main Location

Traditionally, many dummies have encoded certain anatomical locations associated with the `MAIN LOCATION` based on an informal descriptor, for example, the neck rather than the more formal cervical spine. If a formal code exists that describes the anatomical location it will be used in lieu of the less formal one.

Many areas within the WIAMan dummy have a concentrated number of uni- and bi-lateral measurement channels, such as the pelvis. Ideally, an anatomically spe-

cific code would be available to explicitly and unambiguously describe the anatomical location. In some cases, this level of granularity is already supported within the available codes, for example, the acetabulum or `ACTB`. Unfortunately, many anatomical channel positions needed by the WIAMan dummy are not included. One possibility is that new codes be added to reflect the needed positions. Although 4 alpha-numeric characters (26 letters plus 10 digits) can, in theory represent well over 1.6 million different locations, maintaining such an extensive dictionary represents administrative challenges. Fortunately, all measurement channels can be unambiguously identified using spacial qualifiers and therefore no new `MAIN LOCATION` codes are necessary. Recall that the ISO Channel Codes are primarily intended to be processed by a machine; thus, multiple spacial qualifiers are not expected to cause any additional burden in practice.

3.2 Fine Location 1

Similar to the Main Location substring, many dummies have used an informal descriptor in this position. For example, the `UP` in the code `NECKUP` represents the upper neck location in the Hybrid III Male dummy. Other dummies have used a numeric qualifier to add additional precision to the location. For example, `THSP04` represents the anatomical equivalent to the 4th vertebra of the thoracic spine in the WorldSID dummy. For the Channel Codes used with the WIAMan dummy, the more precise, numeric qualifier is used.

3.3 Fine Location 3

The Fine Location 3 substring is associated with the test object (i.e., dummy). This is a 2-digit code which because of the size, limits the ability for the code to be self-descriptive in the general case. As the Channel Code is intended to be primarily machine-readable, the inability to concisely embed all adjectives associated with the WIAMan dummy or any potential WIAMan family does not pose a significant issue. Although the code `WM` would seem a straightforward choice, the codes `WS` and `WF` are already taken to represent the WorldSID Dummy and the WorldSID Small Adult Female Dummy, respectively. The ISO channel coding system does not inherently support the concept of a "namespace", but this selection avoids the `W` prefix to allow for any potential expansion of the WorldSID family. The selected `FINE LOCATION 3` code for the WIAMan dummy is `DM` representing the US Department of Defense average Army male. The `D` prefix is unused within the existing

FINE LOCATION 3 codes and can therefore support a future WIAMan dummy family if needed.

3.4 Quasi-static Measurement Codes

The WIAMan dummy is currently unique in the quantity of quasi-static measurements available due to the design of the dummy's instrumentation package. The dummy employs a network of modular, 6-channel data-acquisition systems (DASs) physically connected directly to the measurement sensor wherever possible. In addition to collecting measurement data from the connected sensor, each DAS also records 3 axes of tilt information, which can be used for pretest positioning. In practice, many of these tilt measurements may be considered redundant either because multiple units are mechanically attached to a rigid structure allowing for rigid-body translation or because the measurement is not needed to uniquely describe the dummy posture. Although Channel Codes could be created only for the most relevant set of raw or mathematically combined tilt measurements, instead all tilt measurements are represented by a unique Channel Code rather than presuppose any possible future use. The drawback to this decision is the large quantity of codes that need to be represented.

Another point of consideration is whether or not the tilt information collected from a directly attached DAS is identified as a separate location from the host sensor. For example, the head 6 degree-of-freedom (6DOF) sensor has an anatomically superior, directly attached DAS with tilt measurements. The Channel Code associated with these tilt measurements could be refined via a FINE LOCATION code of TP or "top" to recognize that its physical location is separate from the 6DOF. It is not clear there is anything to be gained from such an approach. Instead, as a design decision the Channel Codes associated with the tilt measurements share the same MAIN and FINE LOCATION 1 as their host sensor. This is possible because the tilt and host sensor measurement PHYSICAL DIMENSION is disjoint and the connection between the DAS and the host sensor is effectively a rigid body. If more than one tilt sensor shares the same approximate anatomical location, for example the T12 load cell DAS and the T12 6DOF DAS, a secondary spacial qualifier is added in Fine Location 2.

3.5 Ambiguity

As the ISO Channel Coding system only allows for 3 qualifiers, the following heuristic is followed to avoid ambiguous mapping of Channel Codes to the physical measurement locations:

1. The `MAIN LOCATION` code is chosen to reflect the most appropriate anatomical location with a preference for formality.
2. If the location reflects an appendage, the `FINE LOCATION 1` qualifies the left or right. Otherwise, this code spacially qualifies the measurement.
3. If 2 measurements share the same `MAIN LOCATION` and `FINE LOCATION 1`, the `FINE LOCATION 2` code will be used to further qualify the location only if the measurements also share the same `PHYSICAL QUANTITY` and `DIRECTION`.

For example, 2 different axes on the same sensor do not require further spacial qualification. Similarly, 2 different measurement types on the same sensor or different sensors at the same location do not require further spacial qualification.

4. Channel Codes by Anatomical Region

4.1 Head

The WIAMan head contains a single 6DOF located near the anatomical center-of-gravity of the head. A 6-channel DAS containing 3 axes of tilt measurements is directly mounted superior to the 6DOF sensor. The `MAIN LOCATION` code for this region is `HEAD` and the permissible codes are shown in Table 1.

Table 1 Channel Codes for the head (`HEAD`)

Abbrev. Channel Code	Description	Measurements
`HEAD 00 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`HEAD 00 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`HEAD 00 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

4.2 Cervical Spine

The WIAMan cervical spine contains a 6-axis load cell near the anatomical location of the C1 vertebra. The C1 load cell DAS containing 3 axes of tilt measurements is directly mounted laterally on the right side. An additional 6-axis load cell is located near the anatomical location of the C7 vertebra. The DAS is mounted anterior to the load cell. The `MAIN LOCATION` code for this region is `CESP` and the permissible codes are shown in Table 2.

Table 2 Channel Codes for the cervical spine (CESP)

Abbrev. Channel Code	Description	Measurements
`CESP 01 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`CESP 01 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`CESP 01 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`CESP 07 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`CESP 07 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`CESP 07 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

4.3 Thoracic Spine

The WIAMan thoracic spine contains a 6DOF sensor near the anatomical location of the T1 vertebra. A DAS containing 3 axes of tilt measurements is directly mounted superior to the T1 6DOF sensor. The Lower Neck Base Spine Box also contains design provisions for an optional DAS that is intended to be available for external dummy measurements. If used, the DAS and the associated 3 axes of tilt measurements are mounted near the anatomical T3 vertebra. A 6-axis load cell is located near the anatomical location of the T5 vertebra. The T5 load cell DAS containing 3 axes of tilt measurements is directly mounted anterior to the load cell. An additional 6-axis load cell is located near the anatomical location of the T12 vertebra. The T12 load cell DAS containing 3 axes of tilt measurements is directly mounted on the left lateral surface. A second 6DOF sensor is mounted posterior to the anatomical location of the T12 load cell. A DAS containing 3 axes of tilt measurements is directly mounted posterior to the T12 6DOF sensor. The `MAIN LOCATION` code for this region is `THSP`, and the permissible codes are shown in Table 3. Although the physical measurement may not be located in the thorax, the 6 optional user-defined measurement channels are listed here due to the physical location of the DAS. The `MAIN LOCATION` code for these optional measurements is `2001`.

Table 3 Channel Codes for the thoracic spine (`THSP`)

Abbrev. Channel Code	Description	Measurements
`THSP 01 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`THSP 01 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`THSP 01 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`2001 {01-06} 00 DM 00 00`	general purpose	custom
`THSP 03 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`THSP 05 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`THSP 05 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`THSP 05 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`THSP 12 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`THSP 12 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`THSP 12 LE DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`THSP 12 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`THSP 12 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`THSP 12 RE DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

4.4 Sternum

The WIAMan sternum contains design provisions for 6DOF sensor located near the anatomical 4th rib attachment. A DAS containing 3 axes of tilt measurements is directly mounted anterior to the T1 6DOF sensor. The `MAIN LOCATION` code for this region is `STRN`, and the permissible codes are shown in Table 4.

Table 4 Channel Codes for the sternum (`STRN`)

Abbrev. Channel Code	Description	Measurements
`STRN 04 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`STRN 04 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`STRN 04 00 DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

4.5 Lumbar Spine

The WIAMan lumbar spine contains a 6-axis load cell located near the anatomical location of the L5 vertebra. The L5 load cell DAS containing 3 axes of tilt measurements is directly mounted anterior to the load cell. A DAS for collection of the coccyx load cell (see Section 4.6) containing 3 axes of tilt measurements is directly mounted on the posterior surface of the L5 load cell. The `MAIN LOCATION` code for this region is `LUSP`, and the permissible codes are shown in Table 5. As the

coccyx load cell only uses 2 channels, 4 additional general purpose, user-locatable channels are available at this location with a `MAIN LOCATION` code of `2002`.

Table 5 Channel Codes for the lumbar spine (`LUSP`)

Abbrev. Channel Code	Description	Measurements
`LUSP 05 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`LUSP 05 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`LUSP 05 FR DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`2002 {01-04} 00 DM 00 00`	general purpose	custom
`LUSP 05 RE DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

4.6 Pelvis

The WIAMan pelvis contains a 2-axis load cell located near the anatomical S3 vertebra and is primarily intended to measure loads imparted onto the coccyx. The S3 (coccyx) load cell DAS is located on the posterior surface of the L5 load cell (see Section 4.5). A 3-axis load cell is located near each of the left and right ischial tuberosity. A 2-axis load cell is located near each of the left and right superior pelvic ramus. A 6DOF sensor is located on the inferior surface of the lumbar to coccyx interface bracket near, but anterior to the anatomical S1. A DAS containing 3 axes of tilt measurements is directly mounted inferior to this pelvis 6DOF sensor. Two additional DAS each with 3 axes of tilt measurements are mounted on the left and right surface of the anterior lumbar to coccyx interface bracket for collection of each of the ischial tuberosity and pelvic rami load-cells. The `MAIN LOCATION` code for this region is `PELV`, and the permissible codes are shown in Table 6. As the ischial tuberosity and pelvic rami load-cells collectively use only 5 channels for each of the left and right sides, an additional general purpose, user-locatable channel is available for each side with a `MAIN LOCATION` code of `2003`.

Table 6 Channel Codes for the pelvis (PELV)

Abbrev. Channel Code	Description	Measurements
PELV RE 00 DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
PELV RE BO DM FO Z	force	F_z
PELV RE BO DM MO Y	bending moment	M_y
PELV BO LE DM FO {X, Y, Z}	force	F_x, F_y, F_z
PELV BO RI DM FO {X, Y, Z}	force	F_x, F_y, F_z
PELV FR LE DM MO {X, Z}	bending moment	M_x, M_z
PELV FR RI DM MO {X, Z}	bending moment	M_x, M_z
PELV FR BO DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
PELV FR BO DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
PELV FR BO DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
2003 LE 01 DM 00 00	general purpose	custom
PELV FR LE DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
2003 RI 01 DM 00 00	general purpose	custom
PELV FR RI DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$

4.7 Femur

Each WIAMan femur contains a 3-axis load cell located near the anatomical femoral neck. A DAS containing 3 axes of tilt measurements is mounted directly below but medial to the anatomical lesser trochanter. A 6DOF sensor is also located below but anterior to the anatomical lesser trochanter. The DAS containing 3 axes of tilt measurements is directly mounted anterior to the 6DOF sensor. A 6-axis load cell is located at approximately the midpoint of the femoral body. The DAS containing 3 axes of tilt measurements is mounted along the medial surface of the femur. The MAIN LOCATION code for this region is FEAC for the femoral neck load cells and FEMR for the remaining femur measurement channels, and the permissible codes are shown in Table 7.

Table 7 Channel Codes for the femur (`FEAC` and `FEMR`)

Abbrev. Channel Code	Description	Measurements
FEAC LE 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
FEAC RI 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
FEMR LE UP DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
FEMR RI UP DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
FEMR LE 00 DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
FEMR LE 00 DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
FEMR LE FR DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
FEMR RI 00 DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
FEMR RI 00 DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
FEMR RI FR DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
FEMR LE 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
FEMR LE 00 DM MO {X, Y, Z}	bending moment	M_x, M_y, M_z
FEMR LE LO DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
FEMR RI 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
FEMR RI 00 DM MO {X, Y, Z}	bending moment	M_x, M_y, M_z
FEMR RI LO DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$

4.8 Knee and Tibia

Each WIAMan leg contains a single axis potentiometer for measuring the angle between the thigh and leg located at the knee. Each tibia contains a 6-axis load cell located proximal to the anatomical midpoint of the tibia body. A DAS containing 3 axes of tilt measurements is mounted directly on the posterior surface of the load cell. A 6DOF sensor is located at the anatomical midpoint of each tibia body on the posterior surface. The DAS containing 3 axes of tilt measurements is directly mounted posterior to the 6DOF sensor. A DAS with 3 axes of tilt measurements for collecting knee angle and calcaneus loads (see Section 4.9) is also located at the anatomical midpoint of each tibia body on the lateral surface. The `MAIN LOCATION` code for this region is `KNEE` for the knee potentiometer and `TIBI` for the remaining tibia measurement channels and the permissible codes are shown in Table 8.

Table 8 Channel Codes for the knee (`KNEE`) and tibia (`TIBI`)

Abbrev. Channel Code	Description	Measurements
`KNEE LE 00 DM AN Y`	angle	θ_y
`KNEE RI 00 DM AN Y`	angle	θ_y
`TIBI LE 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`TIBI LE 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`TIBI LE UP DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`TIBI RI 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`TIBI RI 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`TIBI RI UP DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`TIBI LE 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`TIBI LE 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`TIBI LE LO DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`TIBI RI 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`TIBI RI 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`TIBI RI LO DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`TIBI LE OU DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`TIBI RI OU DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

4.9 Foot and Heel

Each WIAMan foot contains a 6DOF sensor located at the dorsal surface of the forefoot. The DAS containing 3 axes of tilt measurements is directly mounted on top of the 6DOF sensor. A 3-axis load cell is located at the approximate location of the anatomical calcaneus. The DAS responsible for collecting these measurements is located on the tibia of the respective leg (see Section 4.8). The `MAIN LOCATION` code for this region is `FOOT` for the 6DOF sensor and `HEEL` for the calcaneus measurement channels, and the permissible codes are shown in Table 9.

Table 9 Channel Codes for the foot (`FOOT`) and calcaneus (`HEEL`)

Abbrev. Channel Code	Description	Measurements
FOOT LE 00 DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
FOOT LE 00 DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
FOOT LE 00 DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
FOOT RI 00 DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
FOOT RI 00 DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
FOOT RI 00 DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
HEEL LE 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
HEEL RI 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z

4.10 Upper Arm

Each WIAMan upper arm contains a 6-channel load cell located distal to the anatomical location of the humeral head of each upper arm. The associated DAS containing 3 axes of tilt measurements is directly mounted on the posterior surface of the load cell. A 6DOF sensor is located near the mid-shaft of the anatomical humerus mounted on the posterior surface. The DAS containing 3 axes of tilt measurements is directly mounted posterior to the 6DOF sensor. A DAS containing 3 axes of tilt measurements for collecting elbow loads and the upper-arm to forearm angle is located immediately distal to the 6DOF on the posterior surface of the anatomical humorous. Each elbow contains a 2-channel load cell at the distal end of the anatomical humorous. Finally, a single axis potentiometer for measuring the angle between the upper arm and forearm is located at the elbow joint. The `MAIN LOCATION` code for the upper arm 6DOF sensors and DAS is `UPAR`. The `MAIN LOCATION` code for the elbow load cell is `ELBJ`, and the permissible codes for both are shown in Table 10. As the elbow load-cell and potentiometer collectively use only three channels for each of the left and right sides, 3 additional general purpose, user-locatable channels are available for each side with a `MAIN LOCATION` code of `2004`.

Table 10 Channel Codes for the upper arm (`UPAR`) and elbow (`ELBJ`)

Abbrev. Channel Code	Description	Measurements
UPAR LE 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
UPAR LE 00 DM MO {X, Y, Z}	bending moment	M_x, M_y, M_z
UPAR LE UP DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
UPAR RI 00 DM FO {X, Y, Z}	force	F_x, F_y, F_z
UPAR RI 00 DM MO {X, Y, Z}	bending moment	M_x, M_y, M_z
UPAR RI UP DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
UPAR LE 00 DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
UPAR LE 00 DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
UPAR LE MI DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
UPAR RI 00 DM AC {X, Y, Z, R}	linear acceleration	a_x, a_y, a_z, a_r
UPAR RI 00 DM AV {X, Y, Z}	angular velocity	v_x, v_y, v_z
UPAR RI MI DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
2004 LE {01-03} DM 00 00	general purpose	custom
UPAR LE LO DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
2004 RI {01-03} DM 00 00	general purpose	custom
UPAR RI LO DM AN {X, Y, Z}	angle	$\theta_x, \theta_y, \theta_z$
ELBJ LE 00 DM MO {X, Y}	bending moment	M_x, M_y
ELBJ RI 00 DM MO {X, Y}	bending moment	M_x, M_y
ELBJ LE 00 DM AN Y	angle	θ_y
ELBJ RI 00 DM AN Y	angle	θ_y

4.11 Forearm

Each WIAMan forearm contains a 6-channel load cell located near the proximal third of the forearm. The associated DAS containing 3 axes of tilt measurements is directly mounted on the medial surface. A 6DOF sensor is located near the mid-shaft of the forearm mounted on the medial surface. The DAS containing 3 axes of tilt measurements is directly mounted medially to the 6DOF sensor. The `MAIN LOCATION` code for this region is `FOAR` and the permissible codes are shown in Table 11.

Table 11 Channel Codes for the forearm (FOAR)

Abbrev. Channel Code	Description	Measurements
`FOAR LE 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`FOAR LE 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`FOAR LE UP DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`FOAR RI 00 DM FO {X, Y, Z}`	force	F_x, F_y, F_z
`FOAR RI 00 DM MO {X, Y, Z}`	bending moment	M_x, M_y, M_z
`FOAR RI UP DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`FOAR LE 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`FOAR LE 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`FOAR LE LO DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$
`FOAR RI 00 DM AC {X, Y, Z, R}`	linear acceleration	a_x, a_y, a_z, a_r
`FOAR RI 00 DM AV {X, Y, Z}`	angular velocity	v_x, v_y, v_z
`FOAR RI LO DM AN {X, Y, Z}`	angle	$\theta_x, \theta_y, \theta_z$

5. Conclusion

This document assigns ISO Channel Codes for all physical measurements applicable to the WIAMan technology demonstrator. The WIAMan ATD is currently under active development by the US Department of Defense and future design changes may necessitate the addition or removal of sensors to the future ATD design in order to achieve the desired biomechanical and durability requirements.

6. References

1. ISO/TC 22/SC 36. ISO/TS 13499:2014 Road vehicles — Multimedia data exchange format for impact tests. Geneva (Switzerland): International Organization for Standardization; 2014.

2. Scherer R, Cesari D, Uchimura T, Kostyniuk G, Page M, Asakawa K, Hautmann E, Bortenschlager K, Sakurai M, Harigae T. Design and evaluation of the WorldSID prototype dummy. In: Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles; 2001 June; Amsterdam, Netherlands.

Appendix. WIAMan Channel Codes

Table A-1 WIAMan assigned Channel Codes

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
HEAD	00	00	DM	AC	R	Head resultant linear acceleration
HEAD	00	00	DM	AC	X	Head X linear acceleration
HEAD	00	00	DM	AC	Y	Head Y linear acceleration
HEAD	00	00	DM	AC	Z	Head Z linear acceleration
HEAD	00	00	DM	AV	X	Head X angular velocity
HEAD	00	00	DM	AV	Y	Head Y angular velocity
HEAD	00	00	DM	AV	Z	Head Z angular velocity
HEAD	00	00	DM	AN	X	Head X tilt from horizontal[a]
HEAD	00	00	DM	AN	Y	Head Y tilt from horizontal[a]
HEAD	00	00	DM	AN	Z	Head Z tilt from horizontal[a]
CESP	01	00	DM	FO	X	C1 X force
CESP	01	00	DM	FO	Y	C1 Y force
CESP	01	00	DM	FO	Z	C1 Z force
CESP	01	00	DM	MO	X	C1 X bending moment
CESP	01	00	DM	MO	Y	C1 Y bending moment
CESP	01	00	DM	MO	Z	C1 Z bending moment
CESP	01	00	DM	AN	X	C1 X tilt from horizontal[a]
CESP	01	00	DM	AN	Y	C1 Y tilt from horizontal[a]
CESP	01	00	DM	AN	Z	C1 Z tilt from horizontal[a]
CESP	07	00	DM	FO	X	C7 X force
CESP	07	00	DM	FO	Y	C7 Y force
CESP	07	00	DM	FO	Z	C7 Z force
CESP	07	00	DM	MO	X	C7 X bending moment
CESP	07	00	DM	MO	Y	C7 Y bending moment
CESP	07	00	DM	MO	Z	C7 Z bending moment
CESP	07	00	DM	AN	X	C7 X tilt from horizontal[a]
CESP	07	00	DM	AN	Y	C7 Y tilt from horizontal[a]
CESP	07	00	DM	AN	Z	C7 Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
THSP	01	00	DM	AC	R	T1 resultant linear acceleration
THSP	01	00	DM	AC	X	T1 X linear acceleration
THSP	01	00	DM	AC	Y	T1 Y linear acceleration
THSP	01	00	DM	AC	Z	T1 Z linear acceleration
THSP	01	00	DM	AV	X	T1 X angular velocity
THSP	01	00	DM	AV	Y	T1 Y angular velocity
THSP	01	00	DM	AV	Z	T1 Z angular velocity
THSP	01	00	DM	AN	X	T1 X tilt from horizontal[a]
THSP	01	00	DM	AN	Y	T1 Y tilt from horizontal[a]
THSP	01	00	DM	AN	Z	T1 Z tilt from horizontal[a]
2000	01	00	DM	00	00	General purpose 1
2000	02	00	DM	00	00	General purpose 2
2000	03	00	DM	00	00	General purpose 3
2000	04	00	DM	00	00	General purpose 4
2000	05	00	DM	00	00	General purpose 5
2000	06	00	DM	00	00	General purpose 6
THSP	03	00	DM	AN	X	T3 X tilt from horizontal[a]
THSP	03	00	DM	AN	Y	T3 Y tilt from horizontal[a]
THSP	03	00	DM	AN	Z	T3 Z tilt from horizontal[a]
THSP	05	00	DM	FO	X	T5 X force
THSP	05	00	DM	FO	Y	T5 Y force
THSP	05	00	DM	FO	Z	T5 Z force
THSP	05	00	DM	MO	X	T5 X bending moment
THSP	05	00	DM	MO	Y	T5 Y bending moment
THSP	05	00	DM	MO	Z	T5 Z bending moment
THSP	05	00	DM	AN	X	T5 X tilt from horizontal[a]
THSP	05	00	DM	AN	Y	T5 Y tilt from horizontal[a]
THSP	05	00	DM	AN	Z	T5 Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
THSP	12	00	DM	FO	X	T12 X force
THSP	12	00	DM	FO	Y	T12 Y force
THSP	12	00	DM	FO	Z	T12 Z force
THSP	12	00	DM	MO	X	T12 X bending moment
THSP	12	00	DM	MO	Y	T12 Y bending moment
THSP	12	00	DM	MO	Z	T12 Z bending moment
THSP	12	LE	DM	AN	X	T12 left X tilt from horizontal[a]
THSP	12	LE	DM	AN	Y	T12 left Y tilt from horizontal[a]
THSP	12	LE	DM	AN	Z	T12 left Z tilt from horizontal[a]
THSP	12	00	DM	AC	R	T12 resultant linear acceleration
THSP	12	00	DM	AC	X	T12 X linear acceleration
THSP	12	00	DM	AC	Y	T12 Y linear acceleration
THSP	12	00	DM	AC	Z	T12 Z linear acceleration
THSP	12	00	DM	AV	X	T12 X angular velocity
THSP	12	00	DM	AV	Y	T12 Y angular velocity
THSP	12	00	DM	AV	Z	T12 Z angular velocity
THSP	12	RE	DM	AN	X	T12 rear X tilt from horizontal[a]
THSP	12	RE	DM	AN	Y	T12 rear Y tilt from horizontal[a]
THSP	12	RE	DM	AN	Z	T12 rear Z tilt from horizontal[a]
STRN	04	00	DM	AC	R	Sternum resultant linear acceleration
STRN	04	00	DM	AC	X	Sternum X linear acceleration
STRN	04	00	DM	AC	Y	Sternum Y linear acceleration
STRN	04	00	DM	AC	Z	Sternum Z linear acceleration
STRN	04	00	DM	AV	X	Sternum X angular velocity
STRN	04	00	DM	AV	Y	Sternum Y angular velocity
STRN	04	00	DM	AV	Z	Sternum Z angular velocity
STRN	04	00	DM	AN	X	Sternum X tilt from horizontal[a]
STRN	04	00	DM	AN	Y	Sternum Y tilt from horizontal[a]
STRN	04	00	DM	AN	Z	Sternum Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
LUSP	05	00	DM	FO	X	L5 X force
LUSP	05	00	DM	FO	Y	L5 Y force
LUSP	05	00	DM	FO	Z	L5 Z force
LUSP	05	00	DM	MO	X	L5 X bending moment
LUSP	05	00	DM	MO	Y	L5 Y bending moment
LUSP	05	00	DM	MO	Z	L5 Z bending moment
LUSP	05	FR	DM	AN	X	L5 front X tilt from horizontal[a]
LUSP	05	FR	DM	AN	Y	L5 front Y tilt from horizontal[a]
LUSP	05	FR	DM	AN	Z	L5 front Z tilt from horizontal[a]
LUSP	05	RE	DM	AN	X	L5 rear X tilt from horizontal[a]
LUSP	05	RE	DM	AN	Y	L5 rear Y tilt from horizontal[a]
LUSP	05	RE	DM	AN	Z	L5 rear Z tilt from horizontal[a]
PELV	RE	00	DM	AN	X	Pelvis rear X tilt from horizontal[a]
PELV	RE	00	DM	AN	Y	Pelvis rear Y tilt from horizontal[a]
PELV	RE	00	DM	AN	Z	Pelvis rear Z tilt from horizontal[a]
PELV	RE	BO	DM	FO	Z	Coccyx X force
PELV	RE	BO	DM	MO	Y	Coccyx Y bending moment
PELV	BO	LE	DM	FO	X	Left ischial X force
PELV	BO	LE	DM	FO	Y	Left ischial Y force
PELV	BO	LE	DM	FO	Z	Left ischial Z force
PELV	BO	RI	DM	FO	X	Right ischial X force
PELV	BO	RI	DM	FO	Y	Right ischial Y force
PELV	BO	RI	DM	FO	Z	Right ischial Z force
PELV	FR	LE	DM	MO	X	Left pubic rami X bending moment
PELV	FR	LE	DM	MO	Z	Left pubic rami Z bending moment
PELV	FR	RI	DM	MO	X	Left pubic rami X bending moment
PELV	FR	RI	DM	MO	Z	Left pubic rami Z bending moment

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
PELV	FR	BO	DM	AC	R	Pelvis resultant linear acceleration
PELV	FR	BO	DM	AC	X	Pelvis X linear acceleration
PELV	FR	BO	DM	AC	Y	Pelvis Y linear acceleration
PELV	FR	BO	DM	AC	Z	Pelvis Z linear acceleration
PELV	FR	BO	DM	AV	X	Pelvis X angular velocity
PELV	FR	BO	DM	AV	Y	Pelvis Y angular velocity
PELV	FR	BO	DM	AV	Z	Pelvis Z angular velocity
PELV	FR	BO	DM	AN	X	Pelvis X tilt from horizontal[a]
PELV	FR	BO	DM	AN	Y	Pelvis Y tilt from horizontal[a]
PELV	FR	BO	DM	AN	Z	Pelvis Z tilt from horizontal[a]
PELV	FR	LE	DM	AN	X	Pelvis left X tilt from horizontal[a]
PELV	FR	LE	DM	AN	Y	Pelvis left Y tilt from horizontal[a]
PELV	FR	LE	DM	AN	Z	Pelvis left Z tilt from horizontal[a]
PELV	FR	RI	DM	AN	X	Pelvis right X tilt from horizontal[a]
PELV	FR	RI	DM	AN	Y	Pelvis right Y tilt from horizontal[a]
PELV	FR	RI	DM	AN	Z	Pelvis right Z tilt from horizontal[a]
FEAC	LE	00	DM	FO	X	Left femoral neck X force
FEAC	LE	00	DM	FO	Y	Left femoral neck Y force
FEAC	LE	00	DM	FO	Z	Left femoral neck Z force
FEAC	RI	00	DM	FO	X	Left femoral neck X force
FEAC	RI	00	DM	FO	Y	Left femoral neck Y force
FEAC	RI	00	DM	FO	Z	Left femoral neck Z force
FEMR	LE	UP	DM	AN	X	L-upper femur X tilt from horizontal[a]
FEMR	LE	UP	DM	AN	Y	L-upper femur Y tilt from horizontal[a]
FEMR	LE	UP	DM	AN	Z	L-upper femur Z tilt from horizontal[a]
FEMR	RI	UP	DM	AN	X	R-upper femur X tilt from horizontal[a]
FEMR	RI	UP	DM	AN	Y	R-upper femur Y tilt from horizontal[a]
FEMR	RI	UP	DM	AN	Z	R-upper femur Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
FEMR	LE	00	DM	AC	R	Left femur resultant linear acceleration
FEMR	LE	00	DM	AC	X	Left femur X linear acceleration
FEMR	LE	00	DM	AC	Y	Left femur Y linear acceleration
FEMR	LE	00	DM	AC	Z	Left femur Z linear acceleration
FEMR	LE	00	DM	AV	X	Left femur X angular velocity
FEMR	LE	00	DM	AV	Y	Left femur Y angular velocity
FEMR	LE	00	DM	AV	Z	Left femur Z angular velocity
FEMR	LE	FR	DM	AN	X	L-front femur X tilt from horizontal[a]
FEMR	LE	FR	DM	AN	Y	L-front femur Y tilt from horizontal[a]
FEMR	LE	FR	DM	AN	Z	L-front femur Z tilt from horizontal[a]
FEMR	RI	00	DM	AC	R	Right femur resultant linear acceleration
FEMR	RI	00	DM	AC	X	Right femur X linear acceleration
FEMR	RI	00	DM	AC	Y	Right femur Y linear acceleration
FEMR	RI	00	DM	AC	Z	Right femur Z linear acceleration
FEMR	RI	00	DM	AV	X	Right femur X angular velocity
FEMR	RI	00	DM	AV	Y	Right femur Y angular velocity
FEMR	RI	00	DM	AV	Z	Right femur Z angular velocity
FEMR	RI	FR	DM	AN	X	R-front femur X tilt from horizontal[a]
FEMR	RI	FR	DM	AN	Y	R-front femur Y tilt from horizontal[a]
FEMR	RI	FR	DM	AN	Z	R-front femur Z tilt from horizontal[a]
FEMR	LE	00	DM	FO	X	Left femur X force
FEMR	LE	00	DM	FO	Y	Left femur Y force
FEMR	LE	00	DM	FO	Z	Left femur Z force
FEMR	LE	00	DM	MO	X	Left femur X bending moment
FEMR	LE	00	DM	MO	Y	Left femur Y bending moment
FEMR	LE	00	DM	MO	Z	Left femur Z bending moment
FEMR	LE	LO	DM	AN	X	L-lower femur X tilt from horizontal[a]
FEMR	LE	LO	DM	AN	Y	L-lower femur Y tilt from horizontal[a]
FEMR	LE	LO	DM	AN	Z	L-lower femur Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
FEMR	RI	00	DM	FO	X	Right femur X force
FEMR	RI	00	DM	FO	Y	Right femur Y force
FEMR	RI	00	DM	FO	Z	Right femur Z force
FEMR	RI	00	DM	MO	X	Right femur X bending moment
FEMR	RI	00	DM	MO	Y	Right femur Y bending moment
FEMR	RI	00	DM	MO	Z	Right femur Z bending moment
FEMR	RI	LO	DM	AN	X	R-lower femur X tilt from horizontal[a]
FEMR	RI	LO	DM	AN	Y	R-lower femur Y tilt from horizontal[a]
FEMR	RI	LO	DM	AN	Z	R-lower femur Z tilt from horizontal[a]
KNEE	LE	00	DM	AN	Y	Left knee Y angle
KNEE	RI	00	DM	AN	Y	Right knee Y angle
TIBI	LE	00	DM	FO	X	Left tibia X force
TIBI	LE	00	DM	FO	Y	Left tibia Y force
TIBI	LE	00	DM	FO	Z	Left tibia Z force
TIBI	LE	00	DM	MO	X	Left tibia X bending moment
TIBI	LE	00	DM	MO	Y	Left tibia Y bending moment
TIBI	LE	00	DM	MO	Z	Left tibia Z bending moment
TIBI	LE	UP	DM	AN	X	L-upper tibia X tilt from horizontal[a]
TIBI	LE	UP	DM	AN	Y	L-upper tibia Y tilt from horizontal[a]
TIBI	LE	UP	DM	AN	Z	L-upper tibia Z tilt from horizontal[a]
TIBI	RI	00	DM	FO	X	Right tibia X force
TIBI	RI	00	DM	FO	Y	Right tibia Y force
TIBI	RI	00	DM	FO	Z	Right tibia Z force
TIBI	RI	00	DM	MO	X	Right tibia X bending moment
TIBI	RI	00	DM	MO	Y	Right tibia Y bending moment
TIBI	RI	00	DM	MO	Z	Right tibia Z bending moment

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
TIBI	RI	UP	DM	AN	X	R-upper tibia X tilt from horizontal[a]
TIBI	RI	UP	DM	AN	Y	R-upper tibia Y tilt from horizontal[a]
TIBI	RI	UP	DM	AN	Z	R-upper tibia Z tilt from horizontal[a]
TIBI	LE	00	DM	AC	R	Left tibia resultant linear acceleration
TIBI	LE	00	DM	AC	X	Left tibia X linear acceleration
TIBI	LE	00	DM	AC	Y	Left tibia Y linear acceleration
TIBI	LE	00	DM	AC	Z	Left tibia Z linear acceleration
TIBI	LE	00	DM	AV	X	Left tibia X angular velocity
TIBI	LE	00	DM	AV	Y	Left tibia Y angular velocity
TIBI	LE	00	DM	AV	Z	Left tibia Z angular velocity
TIBI	LE	LO	DM	AN	X	L-lower tibia X tilt from horizontal[a]
TIBI	LE	LO	DM	AN	Y	L-lower tibia Y tilt from horizontal[a]
TIBI	LE	LO	DM	AN	Z	L-lower tibia Z tilt from horizontal[a]
TIBI	RI	00	DM	AC	R	Right tibia resultant linear acceleration
TIBI	RI	00	DM	AC	X	Right tibia X linear acceleration
TIBI	RI	00	DM	AC	Y	Right tibia Y linear acceleration
TIBI	RI	00	DM	AC	Z	Right tibia Z linear acceleration
TIBI	RI	00	DM	AV	X	Right tibia X angular velocity
TIBI	RI	00	DM	AV	Y	Right tibia Y angular velocity
TIBI	RI	00	DM	AV	Z	Right tibia Z angular velocity
TIBI	RI	LO	DM	AN	X	R-lower tibia X tilt from horizontal[a]
TIBI	RI	LO	DM	AN	Y	R-lower tibia Y tilt from horizontal[a]
TIBI	RI	LO	DM	AN	Z	R-lower tibia Z tilt from horizontal[a]
TIBI	LE	OU	DM	AN	X	L-outer tibia X tilt from horizontal[a]
TIBI	LE	OU	DM	AN	Y	L-outer tibia Y tilt from horizontal[a]
TIBI	LE	OU	DM	AN	Z	L-outer tibia Z tilt from horizontal[a]
TIBI	RI	OU	DM	AN	X	R-outer tibia X tilt from horizontal[a]
TIBI	RI	OU	DM	AN	Y	R-outer tibia Y tilt from horizontal[a]
TIBI	RI	OU	DM	AN	Z	R-outer tibia Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
FOOT	LE	00	DM	AC	R	Left foot resultant linear acceleration
FOOT	LE	00	DM	AC	X	Left foot X linear acceleration
FOOT	LE	00	DM	AC	Y	Left foot Y linear acceleration
FOOT	LE	00	DM	AC	Z	Left foot Z linear acceleration
FOOT	LE	00	DM	AV	X	Left foot X angular velocity
FOOT	LE	00	DM	AV	Y	Left foot Y angular velocity
FOOT	LE	00	DM	AV	Z	Left foot Z angular velocity
FOOT	LE	00	DM	AN	X	Left foot X tilt from horizontal[a]
FOOT	LE	00	DM	AN	Y	Left foot Y tilt from horizontal[a]
FOOT	LE	00	DM	AN	Z	Left foot Z tilt from horizontal[a]
FOOT	RI	00	DM	AC	R	Right foot resultant linear acceleration
FOOT	RI	00	DM	AC	X	Right foot X linear acceleration
FOOT	RI	00	DM	AC	Y	Right foot Y linear acceleration
FOOT	RI	00	DM	AC	Z	Right foot Z linear acceleration
FOOT	RI	00	DM	AV	X	Right foot X angular velocity
FOOT	RI	00	DM	AV	Y	Right foot Y angular velocity
FOOT	RI	00	DM	AV	Z	Right foot Z angular velocity
FOOT	RI	00	DM	AN	X	Right foot X tilt from horizontal[a]
FOOT	RI	00	DM	AN	Y	Right foot Y tilt from horizontal[a]
FOOT	RI	00	DM	AN	Z	Right foot Z tilt from horizontal[a]
HEEL	LE	00	DM	FO	X	Left calcaneus X force
HEEL	LE	00	DM	FO	Y	Left calcaneus Y force
HEEL	LE	00	DM	FO	Z	Left calcaneus Z force
HEEL	RI	00	DM	FO	X	Right calcaneus X force
HEEL	RI	00	DM	FO	Y	Right calcaneus Y force
HEEL	RI	00	DM	FO	Z	Right calcaneus Z force
UPAR	LE	00	DM	FO	X	Left upper arm X force
UPAR	LE	00	DM	FO	Y	Left upper arm Y force
UPAR	LE	00	DM	FO	Z	Left upper arm Z force

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
UPAR	LE	00	DM	MO	X	Left upper arm X bending moment
UPAR	LE	00	DM	MO	Y	Left upper arm Y bending moment
UPAR	LE	00	DM	MO	Z	Left upper arm Z bending moment
UPAR	LE	UP	DM	AN	X	L-upper up-arm X tilt from horizontal[a]
UPAR	LE	UP	DM	AN	Y	L-upper up-arm Y tilt from horizontal[a]
UPAR	LE	UP	DM	AN	Z	L-upper up-arm Z tilt from horizontal[a]
UPAR	RI	00	DM	FO	X	Right upper arm X force
UPAR	RI	00	DM	FO	Y	Right upper arm Y force
UPAR	RI	00	DM	FO	Z	Right upper arm Z force
UPAR	RI	00	DM	MO	X	Right upper arm X bending moment
UPAR	RI	00	DM	MO	Y	Right upper arm Y bending moment
UPAR	RI	00	DM	MO	Z	Right upper arm Z bending moment
UPAR	RI	UP	DM	AN	X	R-upper up-arm X tilt from horizontal[a]
UPAR	RI	UP	DM	AN	Y	R-upper up-arm Y tilt from horizontal[a]
UPAR	RI	UP	DM	AN	Z	R-upper up-arm Z tilt from horizontal[a]
UPAR	LE	00	DM	AC	R	L up-arm resultant linear acceleration
UPAR	LE	00	DM	AC	X	Left up-arm X linear acceleration
UPAR	LE	00	DM	AC	Y	Left up-arm Y linear acceleration
UPAR	LE	00	DM	AC	Z	Left up-arm Z linear acceleration
UPAR	LE	00	DM	AV	X	Left up-arm X angular velocity
UPAR	LE	00	DM	AV	Y	Left up-arm Y angular velocity
UPAR	LE	00	DM	AV	Z	Left up-arm Z angular velocity
UPAR	LE	MI	DM	AN	X	L-mid up-arm X tilt from horizontal[a]
UPAR	LE	MI	DM	AN	Y	L-mid up-arm Y tilt from horizontal[a]
UPAR	LE	MI	DM	AN	Z	L-mid up-arm Z tilt from horizontal[a]
UPAR	RI	00	DM	AC	R	R up-arm resultant linear acceleration
UPAR	RI	00	DM	AC	X	Right up-arm X linear acceleration
UPAR	RI	00	DM	AC	Y	Right up-arm Y linear acceleration
UPAR	RI	00	DM	AC	Z	Right up-arm Z linear acceleration

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
UPAR	RI	00	DM	AV	X	Right up-arm X angular velocity
UPAR	RI	00	DM	AV	Y	Right up-arm Y angular velocity
UPAR	RI	00	DM	AV	Z	Right up-arm Z angular velocity
UPAR	RI	MI	DM	AN	X	R-mid up-arm X tilt from horizontal[a]
UPAR	RI	MI	DM	AN	Y	R-mid up-arm Y tilt from horizontal[a]
UPAR	RI	MI	DM	AN	Z	R-mid up-arm Z tilt from horizontal[a]
UPAR	LE	LO	DM	AN	X	L-lower up-arm X tilt from horizontal[a]
UPAR	LE	LO	DM	AN	Y	L-lower up-arm Y tilt from horizontal[a]
UPAR	LE	LO	DM	AN	Z	L-lower up-arm Z tilt from horizontal[a]
UPAR	RI	LO	DM	AN	X	L-lower up-arm X tilt from horizontal[a]
UPAR	RI	LO	DM	AN	Y	L-lower up-arm Y tilt from horizontal[a]
UPAR	RI	LO	DM	AN	Z	L-lower up-arm Z tilt from horizontal[a]
ELBJ	LE	00	DM	MO	X	Left elbow X bending moment
ELBJ	LE	00	DM	MO	Y	Left elbow Y bending moment
ELBJ	RI	00	DM	MO	X	Right elbow X bending moment
ELBJ	RI	00	DM	MO	Y	Right elbow Y bending moment
ELBJ	LE	00	DM	AN	Y	Left elbow Y angle
ELBJ	RI	00	DM	AN	Y	Left elbow Y angle
FOAR	LE	00	DM	FO	X	Left forearm X force
FOAR	LE	00	DM	FO	Y	Left forearm Y force
FOAR	LE	00	DM	FO	Z	Left forearm Z force
FOAR	LE	00	DM	MO	X	Left forearm X bending moment
FOAR	LE	00	DM	MO	Y	Left forearm Y bending moment
FOAR	LE	00	DM	MO	Z	Left forearm Z bending moment
FOAR	LE	UP	DM	AN	X	L-upper forearm X tilt from horizontal[a]
FOAR	LE	UP	DM	AN	Y	L-upper forearm Y tilt from horizontal[a]
FOAR	LE	UP	DM	AN	Z	L-upper forearm Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

Table A-1 WIAMan assigned Channel Codes (continued)

Main	Fine 1	Fine 2	Fine 3	Phys	Dir	Description
FOAR	RI	00	DM	FO	X	Right forearm X force
FOAR	RI	00	DM	FO	Y	Right forearm Y force
FOAR	RI	00	DM	FO	Z	Right forearm Z force
FOAR	RI	00	DM	MO	X	Right forearm X bending moment
FOAR	RI	00	DM	MO	Y	Right forearm Y bending moment
FOAR	RI	00	DM	MO	Z	Right forearm Z bending moment
FOAR	RI	UP	DM	AN	X	R-upper forearm X tilt from horizontal[a]
FOAR	RI	UP	DM	AN	Y	R-upper forearm Y tilt from horizontal[a]
FOAR	RI	UP	DM	AN	Z	R-upper forearm Z tilt from horizontal[a]
FOAR	LE	00	DM	AC	R	L forearm resultant linear acceleration
FOAR	LE	00	DM	AC	X	Left forearm X linear acceleration
FOAR	LE	00	DM	AC	Y	Left forearm Y linear acceleration
FOAR	LE	00	DM	AC	Z	Left forearm Z linear acceleration
FOAR	LE	00	DM	AV	X	Left forearm X angular velocity
FOAR	LE	00	DM	AV	Y	Left forearm Y angular velocity
FOAR	LE	00	DM	AV	Z	Left forearm Z angular velocity
FOAR	LE	LO	DM	AN	X	Left forearm X tilt from horizontal[a]
FOAR	LE	LO	DM	AN	Y	Left forearm Y tilt from horizontal[a]
FOAR	LE	LO	DM	AN	Z	Left forearm Z tilt from horizontal[a]
FOAR	RI	00	DM	AC	R	R forearm resultant linear acceleration
FOAR	RI	00	DM	AC	X	Right forearm X linear acceleration
FOAR	RI	00	DM	AC	Y	Right forearm Y linear acceleration
FOAR	RI	00	DM	AC	Z	Right forearm Z linear acceleration
FOAR	RI	00	DM	AV	X	Right forearm X angular velocity
FOAR	RI	00	DM	AV	Y	Right forearm Y angular velocity
FOAR	RI	00	DM	AV	Z	Right forearm Z angular velocity
FOAR	RI	LO	DM	AN	X	Right forearm X tilt from horizontal[a]
FOAR	RI	LO	DM	AN	Y	Right forearm Y tilt from horizontal[a]
FOAR	RI	LO	DM	AN	Z	Right forearm Z tilt from horizontal[a]

[a]Intended for quasi-static pretest positioning measurements

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	K BOSCH
	C FOSTER
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	J TICE
	T HOLDREN
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	G DIETRICH
	K SANDORA
	RDRL-SLB-W
	W MERMAGEN
	R BOWERS
	RDRL-WMP-F
	N GNIAZDOWSKI
	J NESTA

INTENTIONALLY LEFT BLANK.